

raphy units, the inability to target some lesions, and the inability of some patients to tolerate the prone position. Centers must have a sufficient volume of biopsies to justify the expense of a single-purpose stereotactic unit, so access to this technique is not yet universally available, although mobile units are in use.

Lesions near the chest wall or in the subareolar cone of breast tissue may be difficult to target. If a patient's breast compresses to less than 2 cm, the 23-mm excursion of the needle must start outside the breast. Ultrasonographic guidance is an effective alternative guidance method in these cases, provided that the lesion can be visualized. Candidates for PCB are patients with a mammographically detected lesion judged to be at high suspicion (70% risk) or moderate to low suspicion (10% to 20% risk) of breast carcinoma. Lesions assessed to be probably benign (less than 2% risk) are best observed mammographically, unless patient anxiety is high.

WILLIAM BRANT, MD  
Sacramento, California

#### REFERENCES

- Brenner RJ, Fajardo L, Fisher PR, et al: Percutaneous core biopsy of the breast: Effect of operator experience and number of samples on diagnostic accuracy. *AJR Am J Roentgenol* 1996; 166:341-346
- Liberman L, Dershaw DD, Rosen PP, et al: Stereotaxic core biopsy of breast carcinoma: Accuracy at predicting invasion. *Radiology* 1995; 194:379-381
- Parker SH, Burbank F, Jackman RJ, et al: Percutaneous large-core breast biopsy: A multi-institutional study. *Radiology* 1994; 193:359-364

### Current Status of Thrombolysis

ARTERIAL THROMBOEMBOLISM is a well-recognized cause of major morbidity and sometimes death. Until recently, the only treatment was surgical: amputation, vascular reconstruction, vascular bypass grafting, and Fogarty balloon embolectomy. With the development of thrombolytic pharmacologic agents, a less invasive method has become available. The first widely used agent, streptokinase, although inexpensive, was prone to hemorrhagic complication, was antigenic with frequent reactions, and could not be administered repeatedly at short intervals. More recently developed agents include tissue plasminogen activator and urokinase. The use of urokinase is associated with few hemorrhagic complications, it is not antigenic, and it is therefore generally accepted as the current agent of choice.

Efficacy has notably improved, and indications have been expanded for thrombolysis. In one method, instead of intravenous administration or simply leaving a catheter dripping urokinase at the leading edge of a thrombosed vessel, a specially designed catheter with many tiny side holes is advanced through a thrombosed segment of vessel. With the end hole occluded by a guide wire, rapid pulses of concentrated urokinase (25,000 units per ml) are delivered with a 1-ml tuberculin syringe. This creates a high-pressure spray through the tiny side slits, directly delivering thrombolytic agent deeply into the clot while macerating it. This advance has led to a pronounced improvement in technical success, fewer hemorrhagic complications, and greatly shortened thrombolytic times.

Procedures can now be measured in minutes to hours rather than hours to days.

Another important advance has been the addition of heparin to the urokinase mixture to impede concurrent rethrombosis. A major advantage to this radiologic approach is that frequently an underlying lesion (that is, stenosis) will be uncovered that predisposes the vessel or bypass graft to thrombose. At the same setting, this stenosis can be definitively treated by balloon angioplasty or stenting with generally excellent results.

Modern thrombolysis techniques have also been a boon for hemodialysis patients. It has enabled vascular access sites to be preserved as long as possible, which is critically important for these patients.

In summary, interventional radiologist-directed thrombolysis should now be considered as a first line of therapy in patients with the following disorders: acute thrombosis of peripheral arteries and bypass grafts, including cases of acute critical ischemia; acute embolism of peripheral arteries or bypass grafts; subacute or chronic arterial or graft thrombosis; thrombosed hemodialysis access grafts; venous thrombosis involving veins proximal to dialysis grafts, thoracic outlet syndromes, or portal veins or stents after transjugular intrahepatic portosystemic shunting procedures.

In experienced hands, a technical success rate of about 95% can be expected. The complication rate is about 8%, most of which are groin hematomas or distal emboli requiring minimal management. Life-threatening complications are rare but include intracranial or gastrointestinal bleeding. Close monitoring of clotting factors is therefore required. Exciting new applications now undergoing clinical trials include emergency thrombolytic therapy for pulmonary embolus and acute thromboembolic cerebrovascular stroke.

JAMES J. SELL, MD  
FREDERICK W. RUPP, MD  
ROBERT J. TELEPAK, MD  
Albuquerque, New Mexico

#### REFERENCES

- Lang EV, Stevick CA: Transcatheter therapy of severe acute lower extremity ischemia. *J Vasc Interv Radiol* 1993; 4:481-488
- Valji K, Bookstein JJ, Roberts AC, Oglevie SB, Pittman C, O'Neill MP: Pulse-spray pharmacomechanical thrombolysis of thrombosed hemodialysis access grafts: Long-term experience and comparison of original and current techniques. *AJR Am J Roentgenol* 1995; 164:1495-1500

### Magnetic Resonance Imaging, Positron Emission Tomography, and Single-Photon-Emission Computed Tomography in Epilepsy

RECENT TECHNOLOGIC ADVANCES in imaging have launched us into an era of improved diagnosis and localization of the pathologic substrate of epilepsy, the epileptogenic zone. Published articles cannot substantiate the use of a solitary modality in investigating a patient with seizures. Because magnetic resonance imaging (MRI), positron emission tomography (PET), and single-photon-emission computed tomography (SPECT) measure

different aspects of brain function and anatomy, including structure, metabolism, and blood flow, respectively, the three modalities are complementary; each makes a unique contribution to the investigation of patients' seizures.

Magnetic resonance imaging exceeds PET and SPECT imaging in its ability to show structural abnormalities. Reported sensitivity and specificity vary. In studies that report the surgical success of seizure control, sensitivities for diagnosis by MRI vary from 80% to 90% for sclerosis due to trauma, infection, or infarction; 90% to 95% for mesial-temporal sclerosis; 90% to 100% for neuronal migration disorder; and 100% for tumor or vascular malformation. High-resolution imaging with three-dimensional volume techniques and 1.5-mm contiguous slices has led to a better detection of cortical dysplasias, hamartomas, and other developmental abnormalities. Three-dimensional data are not necessarily viewed in three-dimensional format, but it allows reformatting of the images in any plane to facilitate distinguishing subtle gyral or cortical abnormalities from normal configurations and to compensate for malalignment of the patient.

For difficult cases in which the electroencephalographic data localize the seizures, but the MRI scan is normal, surface rendering of three-dimensional volume data obtained with MRI has helped radiologists to detect previously occult structural abnormalities. Mesial-temporal sclerosis, the most common cause of temporal lobe epilepsy, is characterized by cell loss and astrogliosis that involves a small portion of the hippocampus. Before advances in spatial resolution, early studies reported MRI to be poorly sensitive to the changes of mesial-temporal sclerosis. The demonstration of atrophy and increased signal in a temporal lobe with high-resolution MRI scans now has a high correlation with successful postsurgical seizure control. Volumetric analysis of MRI images has further improved the sensitivity of MRI in the diagnosis of mesial-temporal sclerosis. Side-to-side differences detected with magnetic resonance-based hippocampal volumetry correlates with cell loss quantified at histology. When electroencephalographic evidence of the start of a unilateral temporal lobe seizure is concordant with predominantly unilateral temporal lobe atrophy by MRI volumetric analysis, there is a greater than 90% chance of an excellent surgical outcome compared with 50% surgical success when volumetric evidence for unilateral atrophy is absent on MRI. The identification of a lesion on MRI in extratemporal areas also correlates with successful postsurgical seizure control.

Functional MRI uses ultrafast scanning techniques to scan patients while they are doing a task that is known to activate specific cortical regions, for example, the sensorimotor cortex. The technique is used to define the relationship of an epileptogenic pathologic substrate (such as tumor) to functionally eloquent cortex before surgical resection and thereby to avoid unacceptable postsurgical deficits.

The structural abnormalities seen with MRI correlate highly with the epileptogenic zone, but are not definitive.

Therefore, MRI cannot be used alone. The epileptogenic zone is highly likely to be within a zone of altered metabolism or blood flow as seen with PET and SPECT, respectively. Both modalities have a relatively high sensitivity—PET, 70% to 80% for interictal scans; SPECT, 73% and 97% for peri-ictal and ictal scans, respectively—and moderate specificity for the diagnosis of temporal lobe epilepsy. Lower sensitivities are seen in patients with extratemporal seizures. Although metabolism and blood flow increase during ictal events and decrease interictally, the detection of metabolic changes by PET with the use of fludeoxyglucose F 18 is known to be more sensitive. Although the spatial resolution for modern clinical PET scanners is typically 5 to 7 mm, the added advantages of wider availability, reduced cost, and greater feasibility of ictal scanning with SPECT after administering hexamethyl-propyleneamine oxime (HMPAO) make this modality the more practical tool. Typical resolution for a modern three-head SPECT camera is 6 to 8 mm. Truly ictal studies are possible with HMPAO-SPECT studies because there is rapid uptake of the radiotracer but little washout, so the functional image represents activity during the time of administration and remains bound to the brain for several hours, which facilitates administering the radiotracer at ictus and scanning as long as four hours later. Seizure localization is most reliable when the radiotracer is administered early at the start of seizures and when a seizure does not propagate or does so minimally.

BRIAN W. CHONG, MD  
DAVID K. SHELTON, MD  
*Sacramento, California*

#### REFERENCES

- Jack CR Jr: Epilepsy: Surgery and imaging. *Radiology* 1993; 189:635-646
- Spencer SS: The relative contributions of MRI, SPECT, and PET imaging in epilepsy. *Epilepsia* 1994; 35(suppl 6):S72-S89
- Valk PE, Laxer KD, Barbaro NM, Knezevic S, Dillon WP, Budinger TF: High-resolution (2.6-mm) PET in partial complex epilepsy associated with mesial temporal sclerosis. *Radiology* 1993; 186:55-58

### Imaging of Appendicitis

MOST PATIENTS WITH acute appendicitis have classic clinical findings and are treated surgically. About a third of patients have atypical or confusing clinical findings and often require radiologic imaging. Abdominal radiographs and barium enema have been used in the past to aid in the diagnosis of acute appendicitis. Recently, the use of real-time ultrasonography and computed tomography (CT) has been advocated in patients with this possible diagnosis. The ultrasound examination involves graded compression in the right lower quadrant and especially in the area of maximal tenderness. Because of advances in technology and familiarization with expected sonographic findings, a normal appendix is frequently visualized, excluding the diagnosis of appendicitis. Diagnostic criteria for acute appendicitis in both children and adults include a distended appendix that is greater than 6 mm in diameter, lacks compressibility and peristalsis, and is constant in shape. Findings that are strongly suggestive include periceal inflammation or abscess. Visualization